

Applicant : Donald V. Smart
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Attorney's Docket No.: 06457-007003

Amendments to the Claims:

This listing of claims replaces all prior versions and listings of claims in the application:

Listing of Claims:

1-56. (canceled)

57. (previously presented): A laser-based method of vaporizing and removing a target link structure on a semiconductor wafer comprising the steps of:

providing a target link structure supported on a silicon substrate, the substrate being part of a semiconductor memory device;

producing a laser beam having a pulse width less than about 8 nanoseconds, an operating repetition rate of 10 kilohertz or higher, and a wavelength less than 1.2microns;

generating computer-controlled timing signals synchronized with position of the laser beam relative to the target link structure;

controllably switching an optical switch based on the timing signals so as to transmit an output pulse of the laser beam to the target link structure on demand, the output pulse rate being controlled by controlling the optical switch;

focusing the output pulse onto the target link structure into a spot diameter;

whereby the spot size and depth of focus is improved relative to a longer wavelength greater than 1.2microns, and the output pulse width limits damage to the substrate.

58. (previously presented): The method of claim 57 further comprising the step of mounting the device on a movable stage.

59. (previously presented): The method of claim 58 wherein the movable stage is a step and repeat stage.

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60. (previously presented): The method of claim 57 wherein the target link structure comprises metal.

61. (previously presented): The method of claim 57 wherein a maximum processing rate exceeding 10,000 target link structures per second is achievable with a repetition rate of greater than 10 KHz.

62. (currently amended): The method of claim 57 wherein the step of generating computer-controlled timing signals includes correlating the timing signals with the position of the laser beam and the target link structure during relative motion between the laser beam and the target link structure;

63. (previously presented): The method of claim 62 further comprising positioning the beam with a galvanometer, and synchronizing the timing signals with the galvanometer positions.

64. (previously presented): The method of claim 57 wherein the optical switch is disposed in an optical path and is positioned beyond the laser cavity and external to the laser cavity;

65. (previously presented): The method of claim 57 wherein the output pulse width is less than 5 nanoseconds.

66. (previously presented): The method of claim 57 wherein the correlating step further comprises providing accuracy of better than .3 microns between the laser beam and the target link structure.

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67. (previously presented): The method of claim 57 wherein the step of controllably switching the optical switch further comprises controlling an acousto-optic modulator to prevent an output beam from reaching a target link structure except when desired, and controlling an acousto-optic modulator to set the output power to a desired level.

68. (previously presented): A laser-based method of vaporizing and removing a target link structure on a semiconductor wafer comprising the steps of:

providing a target link structure supported on a silicon substrate, the substrate being part of a semiconductor memory device

producing a laser beam having a pulse width less than about 8 nanoseconds, an operating repetition rate of 5 kHz or higher, at a first laser wavelength;

generating computer-controlled timing signals synchronized with position of the laser beam relative to the target link structure;

shifting the first laser wavelength to a second laser wavelength, the second wavelength being less than 1.2microns;

controllably switching an optical switch based on the timing signals so as to transmit an output pulse of the laser beam to the target link structure on demand, the output pulse rate and pulse spacing being controlled by the controlling the optical switch;

focusing the laser output pulse onto the target link structure into a spot diameter, the output pulse having a wavelength less than 1.2microns and a pulse width less than about 8 nanoseconds;

whereby the spot size and depth of focus is improved relative to a longer wavelength greater than 1.2microns, and the output pulse width limits damage to the substrate.

69. (previously presented): The method of claim 68 further comprising the step of mounting the device on a movable stage.

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70. (previously presented): The method of claim 69 wherein the movable stage is a step and repeat stage.

71. (previously presented): The method of claim 68 wherein the target link structure comprises metal.

72. (previously presented): The method of claim 68 wherein a maximum processing rate exceeding 10,000 target link structures per second is achievable with a repetition rate of greater than 10 kHz.

73. (currently amended): The method of claim 68 wherein the step of generating computer-controlled timing signals includes correlating the timing signals with the position of the laser beam and the target link structure during relative motion between the laser beam and the target link structure.

74. (previously presented): The method of claim 68 wherein the optical switch is disposed in an optical path between a wafer and a laser, and is positioned beyond the laser cavity and external to the laser cavity.

75. (previously presented): The method of claim 68 wherein one of the first and second wavelengths is beyond the absorption edge of the silicon substrate and one of the first and second wavelengths is not beyond the absorption edge of the substrate.

76. (previously presented): The method of claim 75 wherein the wavelength less than the absorption edge is less than about 1.12 microns.

77. (previously presented): The method of claim 76 wherein the wavelength less than the absorption edge is about 1.047 microns.

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78. (previously presented): The method of claim 76 wherein the wavelength less than the absorption edge is about 1.064 microns.

79. (previously presented): The method of claim 71 wherein both the first and second wavelengths are less than 1.2 microns.

80. (previously presented): The method of claim 71 further comprising positioning the beam with a galvanometer, and synchronizing the timing signals with the galvanometer positions;

81. (previously presented): The method of claim 71 wherein the output pulse width is less than 5 nanoseconds.

82. (previously presented): The method of claim 71 wherein the correlating step further comprises providing accuracy of better than .3 microns between the laser beam and the target link structure.

83. (previously presented): The method of claim 71 wherein the step of controllably switching the optical switch further comprises controlling an acousto-optic modulator to prevent an output beam from reaching a target link structure except when desired, and controlling an acousto-optic modulator to set the output power to a desired level.

84. (previously presented): A method of vaporizing and removing a target link structure on a silicon substrate, comprising the steps of:
providing a controlled, switched laser system comprising a diode-pumped, solid-state laser assembly and a controllable switch for controlling the on/off state and power level of the laser assembly;

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producing a laser beam output having an output pulse width less than about 8 nanoseconds at an operating repetition rate of about 5 kilohertz or higher, and a wavelength shorter than 1.2 microns; and

directing the laser beam output at the target link structure on the silicon substrate to vaporize and remove the target link structure;

whereby heating of the silicon substrate and hence damage to the silicon substrate is limited due to the output pulse width being less than about 8 nanoseconds.

85. (previously presented): A laser system for vaporizing and removing a target link structure on a semiconductor wafer, comprising:

a laser assembly configured to produce a laser beam having a pulse width less than about 8 nanoseconds, an operating repetition rate of 10 kilohertz or higher, and a wavelength of less than 1.2 microns;

a computer programmed to control timing signals synchronized with position of the laser beam relative to a target link structure supported on a silicon substrate, the substrate being part of a semiconductor memory device; and

an optical switch that is controllably switchable based on the timing signals so as to transmit an output pulse of the laser beam to the target link structure on demand, the output pulse rate being controllable by controlling the optical switch, the laser assembly being configured to focus the output pulse onto the target link structure into a spot diameter;

whereby the spot size and depth of focus is improved relative to a longer wavelength greater than 1.2 microns, and the output pulse width limits damage to the substrate.

86. (previously presented): A laser system for vaporizing and removing a target link structure on a semiconductor wafer, comprising:

a laser assembly configured to produce a laser beam having a pulse width less than about 8 nanoseconds, an operating repetition rate of 10 kilohertz or higher, and a first wavelength, and

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configured to shift the first laser wavelength to a second laser wavelength, the second wavelength being less than 1.2microns;

a computer programmed to control timing signals synchronized with position of the laser beam relative to a target link structure supported on a silicon substrate, the substrate being part of a semiconductor memory device; and

an optical switch that is controllably switchable based on the timing signals so as to transmit an output pulse of the laser beam to the target link structure on demand, the output pulse rate being controllable by controlling the optical switch, the laser assembly being configured to focus the output pulse onto the target link structure into a spot diameter;

whereby the spot size and depth of focus is improved relative to a longer wavelength greater than 1.2microns, and the output pulse width limits damage to the substrate.

87. (previously presented): A controlled, switched laser system for vaporizing and removing a target link structure on a silicon substrate, comprising:

a diode-pumped, solid-state laser assembly;

a controllable switch for controlling the on/off state and power level of the laser assembly; and

a computer programmed to control the laser assembly to cause the laser assembly to produce a laser beam output having an output pulse width less than about 8 nanoseconds at an operating repetition rate of 5 kilohertz or higher, and a wavelength shorter than 1.2 microns, the computer being programmed to cause the laser beam output to be directed at the target link structure on the silicon substrate to vaporize and remove the target link structure;

whereby heating of the silicon substrate and hence damage to the silicon substrate is limited due to the output pulse width being less than about 8 nanoseconds.

88. (new): A laser-based method of vaporizing and removing a target link structure on a semiconductor wafer comprising the steps of:

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providing a target link structure supported on a silicon substrate, the substrate being part of a semiconductor memory device;

producing a laser beam having a pulse width less than about 10 nanoseconds, an operating repetition rate of 5 kilohertz or higher, and a wavelength less than 1.2microns;

generating computer-controlled timing signals synchronized with position of the laser beam relative to the target link structure;

controllably switching an optical switch based on the timing signals so as to transmit an output pulse of the laser beam to the target link structure on demand, the output pulse rate being controlled by controlling the optical switch;

focusing the output pulse onto the target link structure into a spot diameter;

whereby the spot size and depth of focus is improved relative to a longer wavelength greater than 1.2microns, and the output pulse width limits damage to the substrate.

89. (new): The laser system of claim 88 wherein the laser beam has a pulse width less than precisely 10 nanoseconds.

90. (new): The laser system of claim 88 wherein the laser beam has an operating repetition rate of 10 kilohertz or higher.

91. (new): A laser system for vaporizing and removing a target link structure on a semiconductor wafer, comprising:

a laser assembly configured to produce a laser beam having a pulse width less than about 10 nanoseconds, an operating repetition rate of 5 kilohertz or higher, and a first wavelength, and configured to shift the first laser wavelength to a second laser wavelength, the second wavelength being less than 1.2microns;

a computer programmed to control timing signals synchronized with position of the laser beam relative to a target link structure supported on a silicon substrate, the substrate being part of a semiconductor memory device; and

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an optical switch that is controllably switchable based on the timing signals so as to transmit an output pulse of the laser beam to the target link structure on demand, the output pulse rate being controllable by controlling the optical switch, the laser assembly being configured to focus the output pulse onto the target link structure into a spot diameter;

whereby the spot size and depth of focus is improved relative to a longer wavelength greater than 1.2microns, and the output pulse width limits damage to the substrate.

92. (new): The method of claim 91 wherein the laser beam has a pulse width less than precisely 10 nanoseconds.

93. (new): The method of claim 91 wherein the laser beam has an operating repetition rate of 10 kilohertz or higher.

94. (new): A method of vaporizing and removing a target link structure on a silicon substrate, comprising the steps of:

providing a computer controlled, diode-pumped, q-switched, solid-state laser assembly;
producing a laser beam output having an output pulse width less than about 10 nanoseconds at an operating repetition rate of about 5 kilohertz or higher, and a wavelength shorter than 1.2 microns; and
focusing the output pulse onto the target link structure into a spot diameter.

95. (new): The method of claim 94 wherein the laser beam has a pulse width less than precisely 10 nanoseconds.

96. (new): The method of claim 94 wherein the laser beam has an operating repetition rate of 10 kilohertz or higher.

97. (new): The method of claim 94 wherein the laser wavelength is about 1.047 microns.

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98. (new): The method of claim 94 wherein the laser wavelength is about 1.064 microns.

99. (new): The method of claim 94 wherein the link is a thin link less than one micron in width, and whereby the spot size and depth of focus is improved relative to a longer wavelength greater than 1.2 microns, and the output pulse width limits damage to the silicon substrate.

100. (new): The method of claim 99 wherein the link is a polysilicon link.

101. (new): The method of claim 99 wherein the link is a metal link.

102. (new): The method of claim 94 wherein the solid state laser system further comprises an optical switch positioned beyond the laser cavity and external to the laser cavity and wherein the method further comprises controllably switching the optical switch based on computer controlled timing signals so as to transmit an output pulse of the laser beam to the target link structure on demand, the output pulse rate and pulse spacing being controlled by the controlling the optical switch.

103. (new): The method of claim 94 wherein the output pulse width is less than about 5 nanoseconds.

104. (new): The method of claim 94 wherein the output pulse width is less than about 8 nanoseconds.

105. (new): A laser system for vaporizing and removing a target link structure on a silicon substrate, comprising:

a diode-pumped, q-switched, solid-state laser assembly;

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a computer programmed to control the laser assembly to cause the laser assembly to produce a laser beam output having an output pulse width less than about 10 nanoseconds at an operating repetition rate of about 5 kilohertz or higher, and a wavelength shorter than 1.2 microns;

the laser assembly being configured to focus the output pulse onto the target link structure into a spot diameter.

136. (new): The system of claim 105 wherein the laser beam output has an output pulse width less than precisely 10 nanoseconds.

107. (new): The system of claim 105 wherein the laser beam output has an operating repetition rate of 10 kilohertz or higher.